INTROSPECTIVE SYSTEMS

Transactive Energy

The Next, Next Grid - A Transactive Energy Future

In our daily lives, we don't think about how the lights turn on. But there is a complex system of generation, transmission and distribution facilities with loads. Much like the light switch example above, we also don't think much about the complexities of Walmart's global supply chain when we buy something. They, however, have many of the same complexities that grid operators encounter. For example, supply and demand determine the price of say, sneakers. When there are lots of sneakers available the price goes down and when sneakers are in short supply the price goes up.

Some of the mechanisms that govern Walmart's global supply can also be used to balance the electric grid. This mechanism is called Transactive Energy. The formal description from the Grid Wise Architecture Council:

> “refer(s) to techniques for managing the generation consumption or flow of electric power within an electric power system through the use of economic or market-based constructs while considering grid reliability constraints.”

> Our definition for Transactive Energy: Energy controls using market-based methods for managing supply and demand in the electric power systems.

A traditional electrical grid is an on-demand system because generators output must meet the demand in real-time. Today grids with Distributed Energy Resources (DER) are becoming prevalent and generation is no longer controllable. A solar array makes power when the sun shines not when the load requires it and are often is variable from day to day, hour to hour or minute to minute. This is one of the reasons that interest in energy storage is high. For instance, in California, the grid operators (CAISO) are trying to address depressed load in the middle of the day (12 pm-3 pm) then very quick ramp-ups to meet load at 6 pm in the evening. This is leading to different operating conditions that require flexible resource capabilities to ensure that renewables can be integrated and the grid maintains reliability.

Flexibility

Systems operators, like CAISO, need new controls and resource mixes to adjust electricity production to meet the sharp changes in electricity demand. To help address this, utility companies are implementing more aggressive demand-side management (DSM) strategies to curtail load. However, these strategies often fall short when variable, intermittent renewable generation is a high percentage of the overall supply. Likewise, simple time-of-use (TOU) strategies for commercial customers do not meet the needs of this new dynamic grid with DER's.

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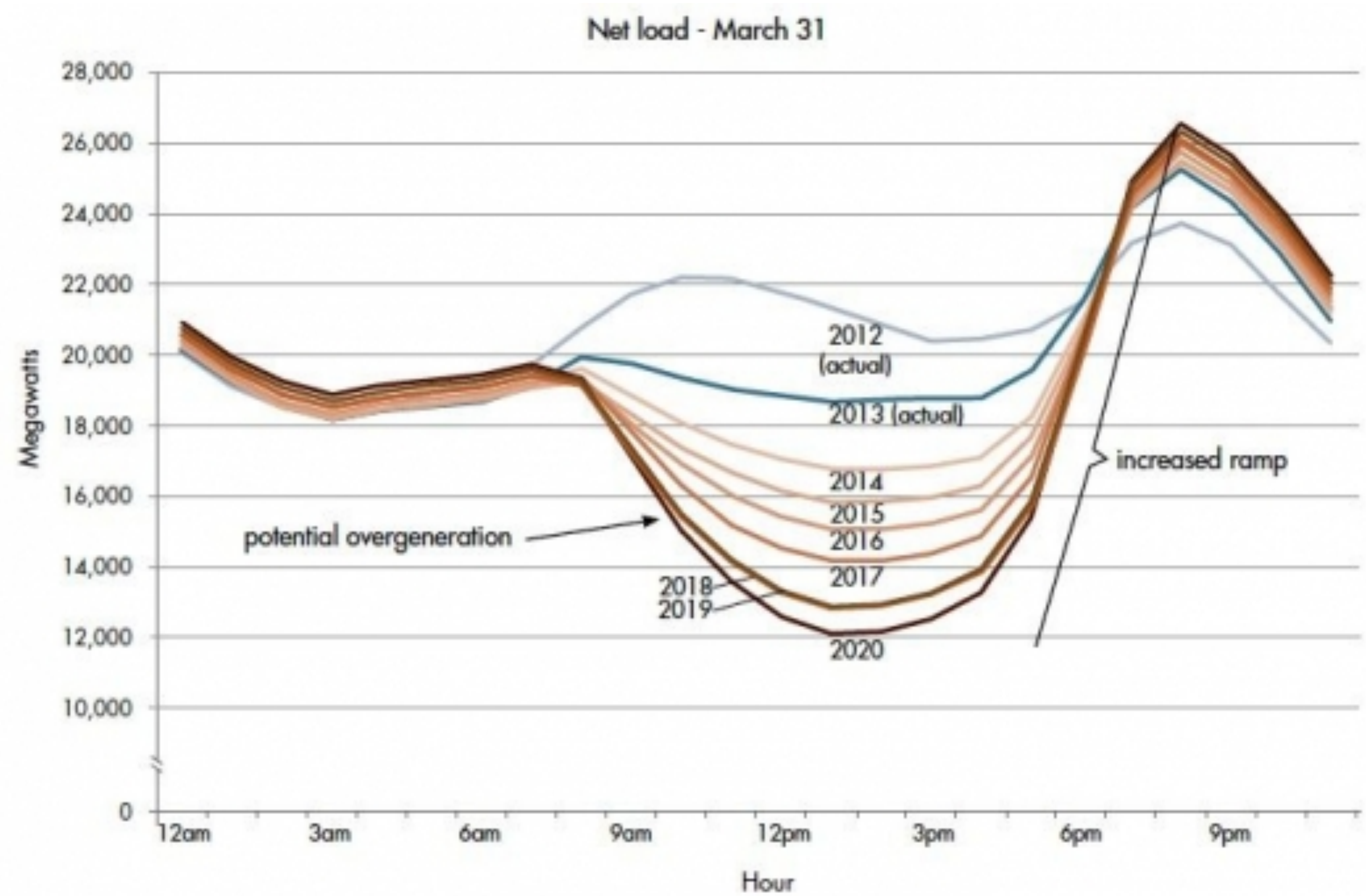
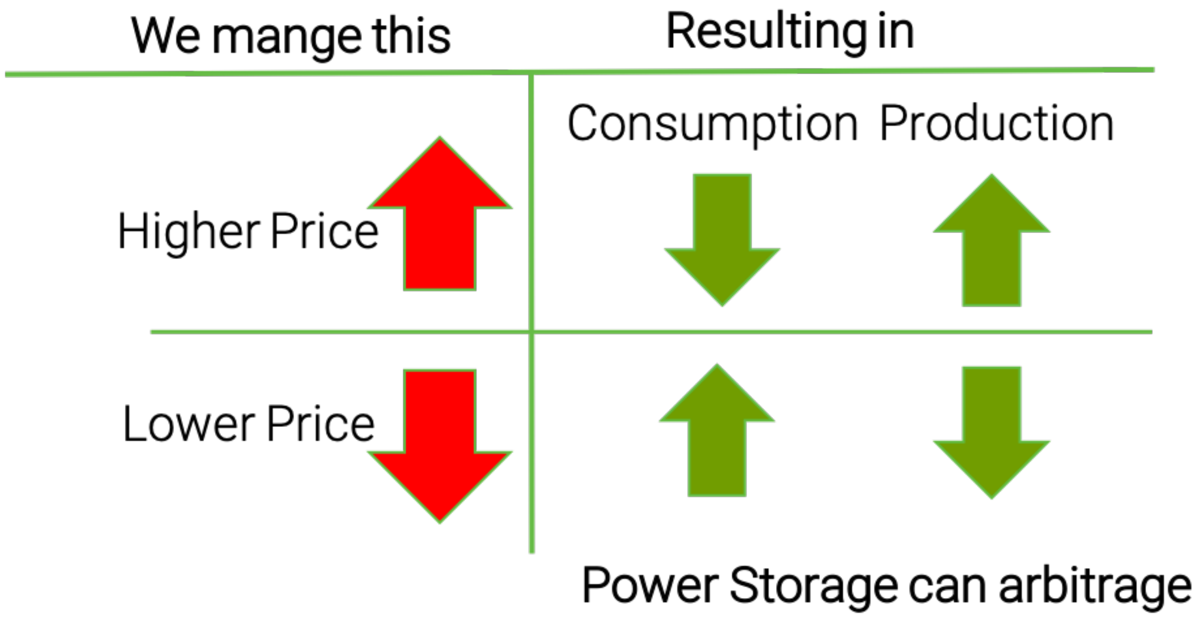


CAISO load curve for March 31, 2018 courtesy of DOE

Our unique method of using a distribution-level real-time pricing signal that is capable of balancing distributed energy resources by applying real-time control of heat pumps, air-conditioners, energy storage or any controllable load that can be deferred or incentivized to operate.

While most Transactive Energy methods incorporate two-way communication and centralized control, Introspective Systems uses a multi-layered structure where real-time pricing is re-calculated at many levels of the grid. The devices themselves (heat pumps, air conditioners, etc.) make their own decision on when it is the most cost-effective to use or provide power (i.e.: a battery). This makes control localized limiting cybersecurity concerns and making the system more responsive. Additionally, in our version of Transactive Energy the consumer is in control of their own devices so if they want to override the artificial intelligence decision making, they can at any time.



Our Isle au Haut microgrid uses these real-time pricing signals and controls to turn heating loads into a flexible (active) demand resources that respond to changes in the abundance or scarcity of power. This integrated solution uses Air to Water (A2W) heat pumps with thermal storage and machine learning algorithms allowing the heat pumps to respond, very flexibly, to a **real-time distributional locational marginal pricing** signal (DLMP), thereby enabling the **load to follow renewable generation**.

When solar and wind production is high, A2W heat pumps “soak” up the extra renewable energy by heating thermal storage tanks located within the buildings, reducing the electrochemical storage capacity of the microgrid. This load shifting provides heat to homes beyond the solar production period, generates significant reductions for subscriber energy costs, and retains within the local community, income that would otherwise be exported for the purchase of fossil fuels. Beyond providing a cost-effective storage solution to the community microgrid, the **value proposition of load-shifting and flexible demand response is generalizable to the entire grid on larger scale grid and smaller scale microgrid projects**.